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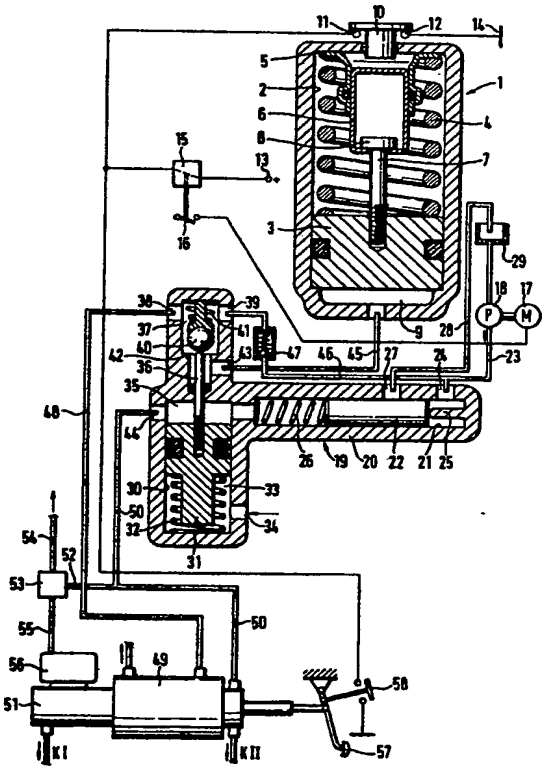
(54) Vehicle hydraulic brake system with auxiliary pressure source

(57) When pedal 57 is operated, pressure fluid from accumulator 1 flows to booster 49, via line 45 open valve 40, 42 and line 48, to actuate circuit KII directly and KI indirectly via master cylinder 51. As the pressure in accumulator chamber 9 drops and pedal switch 58 closes, pump motor 17 is actuated and pump 18 takes over the supply of fluid to the booster via line 23 non-return valve 47 and line 48. At the same time valve 40, 42 closes due to booster pressure acting on valve piston 31. This prevents the accumulator 1 from being charged during braking so avoiding loss of pressure at the brakes. After braking, switch 58 opens but if the accumulator pressure is low, switch 10 is closed and keeps the pumps operating to re-charge the accumulator via the now open valve 40, 42. Valve 19 monitors the pressure applied to the accumulator. Valve 53 controls the relief of booster pressure to master cylinder reservoir 56 and/or pump reservoir (via line 54) for brake slip control.



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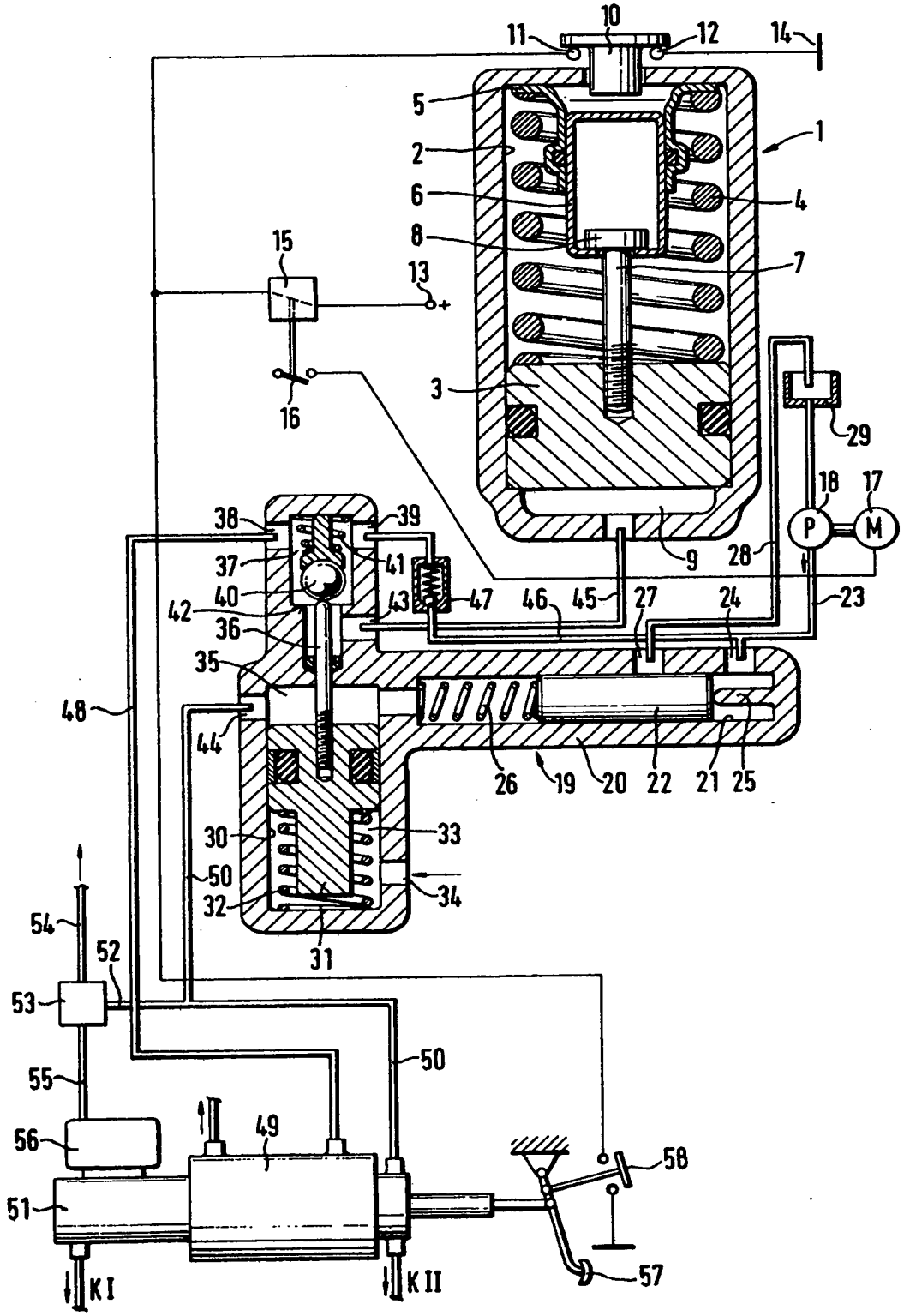
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SPECIFICATION

Hydraulic brake system

This invention relates to a hydraulic brake system for automotive vehicles with a master brake cylinder and with a power booster connected upstream of the master brake cylinder.

Brake systems of this type sometimes have a pressure medium pump which may be driven by an electric motor for providing auxiliary hydraulic energy, the drive of which may be switched on by a pressure accumulator, on the one hand, and by a brake pedal contact, on the other hand. In the unbraked condition of the automotive vehicle the pressure accumulator is maintained at a pressure level sufficient for an initial actuation of the brake and the charge of the pressure accumulator is monitored by a pressure control valve.

A hydraulic brake system featuring the above characteristics is described in German patent application no. P 32 47 498.9. In the hydraulic brake system according to this prior suggestion the delivery side of the pressure medium pump communicates with the inlet of a pressure medium accumulator via a pressure control valve. Thus during the operation of the automotive vehicle there is always a predeterminable fluid volume available in the pressure accumulator. To this end, the pressure accumulator has an electric contact which is operable in dependence on the charge of the pressure accumulator and which is connected with the electric motor drive of the pressure medium pump.

In the known hydraulic brake system the pressure control valve consequently only serves to monitor the accumulator charge of the hydropneumatic pressure accumulator. As soon as an actuating force is exerted on the brake pedal and the power booster, connected upstream of the master brake cylinder, adopts an operating position, the fluid volume available in the pressure accumulator is supplied to the hydraulic power booster. Thus there is an auxiliary force assistance early in the initial phase of the braking action although there is no need for the pressure medium pump to operate in the initial phase of braking.

Due to the relatively small accumulator volume of the hydropneumatic pressure accumulator the pressure fluid volume that is accumulated in the pressure accumulator is depleted relatively quickly. Thus an electric contact at the pressure accumulator is closed which switches on the electric motor drive of the pressure medium pump. Thus, upon a continued braking action, the delivery side of the pressure medium pump permanently communicates with the hydraulic power booster. Thus the delivery provided by the pressure medium pump is available as auxiliary energy at the hydraulic power booster.

The described brake system has the disadvantage that the pressure medium pump whose drive, upon the brake's actuation, remains switched on permanently, due to a respective brake pedal contact, also wants to charge the pressure accumulator of the hydraulic brake system. Thus, at least partially the delivery provided by the pressure medium pump is led into two channels connected in parallel, the hydraulic power booster of the brake system, of course, not being provided with the maximum delivery of the pressure medium pump. Even upon an actuation of the brake, there will be a recharging of the pressure medium accumulator after the pressure medium accumulator had been discharged. Thus, it is possible that the delivery pressure of the pressure medium pump required at the hydraulic power booster will, at least temporarily, not be available.

The present invention seeks to further develop a hydraulic brake system of the type referred to above so as to prevent a new recharging of the pressure medium accumulator after the depletion of the pressure medium accumulator upon the actuation of the brake so that the entire auxiliary energy of the pressure medium pump is directly available to the hydraulic brake booster.

According to the invention there is provided a hydraulic brake system for automotive vehicles with a master brake cylinder and a hydraulic power booster connected upstream ofthe master brake cylinder, in which a pressure medium pump which may be driven by an electric motor is used for providing auxiliary hydraulic energy, the drive of which may be switched on by a pressure accumulator, on the one hand, and by a brake pedal contact, on the other hand, in the unbraked operation of the automotive vehicle the pressure accumulator is maintained at a pressure level sufficient for an initial actuation of the brake and the charge of the pressure accumulator is monitored by a pressure control valve, characterised in that a valve passage of a valve arrangement is operable by a hydraulic pressure in the booster chamber of the power booster such as to establish a direct communication between the outlet of the pressure medium pump and the pressure port of the power booster.

The result of this invention is that the contents of the pressure accumulator are depleted relatively fast in the initial phase of the brake's actuation, a sufficient auxiliary force assistance being guaranteed, though. The pressure medium pump controllable via a brake pedal contact, amongst others, also starts operating upon the actuation of the brake. Thus, after the depletion of the pressure medium volume accumulated in the pressure medium accumulator there is only the pressure medium pump available for providing an auxiliary energy. However, the pressure medium accumulator is prevented from being

recharged, thus the entire pressure medium supplied by the pressure medium pump is supplied to the hydraulic power booster.

In a refinement of the invention the valve arrangement has a valve passage which, upon the pressurisation of the booster chamber, interrupts the communication between the pressure accumulator and the hydraulic power booster. To this end there may be provided, in a cylinder bore of the valve arrangement, a control piston which is displaceable by the delivery pressure of the pressure medium pump against a control force and which establishes a communication between the delivery side of the pressure medium pump and an unpressurised supply reservoir. In such an arrangement there is the advantageous result that the pressure accumulator is always charged up to a structurally predetermined value if the automotive vehicle is not braked. In this operating phase, the control piston of the valve arrangement only acts as pressure control valve controlling the accumulator volume. A compression spring may be arranged to load the control piston contrary to the pressurisation by the pressure medium pump and may be rated such as to ensure that the pressure accumulator has an energy capacity sufficient to assist the braking action in the initial phase of braking. The control force acting on the control piston is expediently generated by a compression spring which may be adjusted so as to be adapted to differently rated automotive vehicle data.

In an advantageous further development of the subject matter of the application it is provided that the front face of the control piston which is loaded by the compression spring confines a control chamber hydraulically communicating with the booster chamber. The result of such an arrangement is that, upon the application of the brake, when at first the contents of the pressure accumulator are supplied to respectively the hydraulic power booster or its pressure chamber, the control piston of the valve arrangement is additionally loaded by a pressure force which displaces the control piston into a final position in which a hydraulic conmunication is blocked between the delivery side of the pressure medium pump and the unpressurised supply reservoir. In such an axial position of the control piston it is thus impossible for the pressure fluid volume provided by the pressure medium pump to escape to the unpressurised supply reservoir, unused. It may be further provided that the control chamber hydraulically communicates with a piston which is displaceable against a compression spring and which may operate a connection between the delivery side of the pressure medium pump and the pressure accumulator. Upon the application of the brake the piston displaceable against the compression spring is displaced by the pressure to be metered and supplied into the booster chamber. Thus a connection is interrupted between the delivery side of the pressure medium pump and the pressure accumulator, a direct communication being established between the delivery side of the pressure medium pump and the inlet of the hydraulic power booster.

As regards lock-up protection of the described brake system it is advantageous if the pressure in the control chamber of the valve arrangement is influenced by an electromagnetically operable multi-position valve which is controllable by slip control electronics. Should the slip control electronics, cooperating with sensors scanning the rotational behaviour of the wheels, detect the presence of critical slip values, the multi-position valve enables reduction of the pressure in the booster chamber of the hydraulic power booster or the control chamber of the valve arrangement. This directly brings about a reduction of the pressure generated in the master brake cylinder. Thus there results a corresponding reduction of the braking force and the brake actuating devices supplied with pressure by the master brake cylinder are pressure-relieved. Due to the reduction of the braking force in the actuating devices of the wheel brakes, in dependence on the coefficients of friction between the tyres of the automotive vehicle and the road surface, there results a reacceleration of the wheels, and a lock-up condition can be averted. Preferably a 3/2-way solenoid valve is used as multi-positon valve. Such a valve provides the possibility of keeping the pressure constant in the control chamber of the valve arrangement or in the booster chamber of the hydraulic power booster. Thus, generally, there exist three possibilities of influencing the effective braking pressure of the brake system in dependence on the respective wheel slip prevailing.

In order that the invention and its various other preferred features may be understood more easily, an embodiment thereof will now be described, by way of example only with reference to the sectional view illustrated in the drawing.

In the drawing, the reference numeral indicates a pressure accumulator in which, in a cylinder bore 2, an accumulator piston 3 is supported such as to be displaceable against a compression spring 4. The compression spring 4 is supported at its opposite end by a spring plate 5 which forms a part of a bowl-type spring retainer 6. An extension 7 to the accumulator piston 3 having an enlarged head 8 projects into the bowl-type spring retainer 6 which is axially displaceable relative to the spring plate 5 in the direction of movement of the accumulator piston 3 of the pressure accumulator 1. Thus, upon a sufficient pressurisation of a chamber 9 averted from the compression spring 4, the head 8 will abut the bowl-type spring retainer 6, lifting an

electric contact 10 off from opposite contacts 11, 12 and thus interrupting an electric connection between the poles 13, 14 of a battery. Connected between the poles 13, 14 is an electromagnetic switching relay 15 which comprises a make contact 16 which may switch on an electric motor 17 which may drive a pressure medium pump 18.

A further component of the brake system is a valve arrangement 19 having a housing 20 provided with a first cylinder bore 21. In the first cylinder bore 21, a control piston 22 is guided. Referring to the drawing, the right-hand front face of the control piston 22 communicates with the delivery side of the pressure medium pump via a pressure line 23 and a housing port 24. In the non-operating condition of the brake system, the control piston 22 rests against an abutment 25 limiting the axial movement of the control piston 22. The axial position of the control piston 22 is established by a compression spring 26. The housing 20 of the valve arrangement 19 has a housing port 27 as well as the housing port 24. In the drawing, the housing port 27 is closed by the control piston 22. An unpressurised supply reservoir 29 is connected to the housing port 27 via a pressure line 28.

In the housing 20 of the valve arrangement 19, a second cylinder bore 30 is provided in which a piston 31 is guided in a sealed manner against the force of a compression spring 32. A chamber 33 of the valve arrangement 19 accommodating the compression spring 32 communicates with the unpressurised supply reservoir 29 via a housing port 34. Referring to the drawing, the upper front face of the piston 31 confines a control chamber 35 hydraulically communicating with a chamber that accommodates a compression spring 26. Further, a tappet 36 is provided on the piston 31. Tappet 36 projects through a seal into a valve chamber 37 having housing ports 38, 39. In the valve chamber 37, a ball 40 is arranged which serves as valve closure member. In the illustrated rest position of the brake system, the ball 40 is lifted off a valve seat 42 by means of the tappet 36 against the force of a compression spring 41. The valve arrangement also has two housing ports 43, 44. The housing port 43 communicates,via a pressure line 45, with the chamber 9 of the pressure accumulator 1. The housing port 39 of the valve arrangement 19 communicates, via pressure line 46, with the delivery side of the pressure medium pump 18 and with the housing port 24 of the valve arrangement 19. Upstream of the housing port 39 of the valve arrangement 19, there is a check valve 47 which prevents the pressure medium from flowing from the housing port 39 to the delivery side of the pressure medium pump.

Via the valve chamber 37 of the valve arrangement 19, a permanent hydraulic passage is established between the housing ports 39, 38, the housing port 38 hydraulically communicating with a hydraulic power booster 49 via a pressure line 48. By means of a brake valve provided in the hydraulic power booster 49, a hydraulic pressure may be adapted to be metered and supplied into the booster chamber of the hydraulic power booster 49. On the one hand, the hydraulic pressure will flow into a second brake circuit KII. On the other hand, the booster chamber conmunicates with the housing port 44 of the valve arrangement 19 via a pressure line 50. Thus, in the control chamber 35 of the valve arrangement 19, there will always be the same hydraulic pressure as in the booster chamber of the hydraulic power booster 49.

The hydraulic power booster is followed by a master cylinder 51 supplying a brake circuit KI. A pressure line 52 branches off from the pressure line 50 of the described brake system and leads to a 3/2-way solenoid valve 53 from which, on the one hand, a pressure line 54 leads to the unpressurised supply reservoir 29 and, on the other hand, a pressure line 55 leads to a storage reservoir 56 of the master cylinder 51. The hydraulic power booster 49 is operable by a brake pedal 57 having a brake pedal contact 58. Upon the actuation of the brake pedal 57, the contact will move into the on-position and will switch on the electromagnetic switching relay and the make contact 16 will close, starting the electric motor 17. Thus the pressure medium pump 18 will supply pressure medium.

The mode of operation of the described brake system will now be explained in more detail. The description of the operation that is to follow starts from the discharged condition of the pressure accumulator 1 as discernible from the drawing. As a rule, this condition is established after a prolonged time of standstill of the automotive vehicle. When starting the automotive vehicle, a positive potential reaches the magnet coil of the electromagnetic switching relay 15 connected with the earth contact 14 so that, via the magnet coil of the electromagnetically operable switching relay 15 and via the pressure accumulator's contact 10, closed in this operating condition, an electric connection will be established between the positive pole 13 of the battery and the earth pole 14. This will cause the electromagnetic switching relay 15 to be excited, thus the make contact 16 closes and the electric motor 17 starts operating. As the pressure medium pump 18 is mechanically connected with the electric motor 17, a flow of pressure medium occurs at the delivery side of the pressure medium pump, the pressure medium flow proceeds to the housing port 24 of the valve arrangement 19 via the pressure line 23. The pressure supplied by the pressure medium pump 18 will also reach the valve chamber 37 of the valve arrangement 19 via the pressure line 46 and the now open

check valve. From the valve chamber 37 of the valve arrangement 19 it will flow to the chamber 9 of the pressure accumulator 1 via the opened valve passage 40, 42 and the pressure line 45. In this operating phase, the control piston 22 of the valve arrangement will maintain its position discernible from the drawing, thus the delivery of the pressure medium pump 18 is directed exclusively to the pressure accumulator 1 where a pressure build-up in chamber 9 occurs which is eventually sufficient to displace the accumulator piston 3 of the pressure accumulator 1 against the force of the compression spring 4 upwards in the drawing. When predeterminable pressure occurs in chamber 9, the pressure accumulator 1 reaches an operating position in which the head 8 connected with the accumulator piston 3 via the extension 7 abuts the upper limit of the bowl-type spring retainer 6. Thus the contact 10 opens. Thereby the electromagnetic switching relay 15 is de-energised, and the contact 16 opens putting the electric motor 17 and the pressure medium pump coupled with the electric motor 17 out of operation. In such a phase of charging of the pressure accumulator the control piston 22 of the valve arrangement 19 ensures that any pressure peaks on the delivery side of the pressure medium pump 18 are relieved towards the unpressurised supply reservoir 29 via the pressure line 28. After a certain charging time, the pressure accumulator 1 reaches a charging condition in which a certain pressurised volume is available in chamber 9. As, via the pressure lines 45, 48, there is a permanent communication between chamber 9 and the accumulator port of the hydraulic power booster, consequently, the accumulator energy is also permanently available at the pressure supply port of the hydraulic power booster 49.

As soon as an actuation of the brake pedal 57 initiates a braking action, pressure medium flows from the pressure line 48 into the booster chamber via the pressure supply port of the hydraulic power booster 49. Thus a booster piston not discernible from the drawing is displaced by the pressurisation of a booster chamber, thereby a corresponding pressure is generated in the master cylinder 51. The pressure adapted to be metered and supplied into the booster chamber of the hydraulic power booster 49 enters the brake circuit KII and pressurise the wheel brakes connected to this brake circuit. In addition, the brake circuit KI is pressurised. Thus, immediately after the application of the brake there is a braking action assisted by the auxiliary hydraulic energy accumulated in the chamber 9 of the pressure accumulator 1. Via the pressure line 50, the booster chamber further communicates with the control chamber 35 of the valve arrangement 19. Thus a pressure adapted to be metered and supplied into the booster chamber, on the one hand, displaces the control piston 22 of the valve arrangement 19 against the axial abutment, assisted by the compression spring 26, while, on the other hand, the upper front face of the piston 31 (see drawing) is pressurised by the dynamic pressure of the hydraulic power booster 49. Thus the piston 31 of the valve arrangement 19 is displaced against the compression spring 32 downwards (in the drawing). After a certain displacement travel the ball 40 comes to rest on the valve seat 42, thus blocking a hydraulic communication between the pressure medium pump 18 and the pressure accumulator 1.

With a force exerted on the brake pedal 57, the brake pedal contact 58 also closes. Thereby the electric motor 17 is switched on permanently and the pressure medium pump 18 permanently supplies pressure at its delivery side. The pressure directly reaches the auxiliary energy port of the hydraulic power booster 49 via the pressure lines 23, 46, 48.

Thus, in the initial phase of braking the auxiliary energy required for the auxiliary force assistance of the brake system is directly obtained from the pressure accumulator 7. Subsequently the pressure medium pump 18 takes over directly the task of providing the auxiliary hydraulic energy. In doing so, via the valve passage 40, 42, a hydraulic communication between the outlet of the pressure medium pump 78 and the chamber 9 of the pressure accumulator is blocked. Thus, the delivery of the pressure medium pump 18 is exclusively supplied to the hydraulic power booster 49, any recharging of the pressure accumulator 1 being prevented until release of the brake pedal 57.

A further component of the described brake system is a 3/2-way solenoid valve 53 which is controllable by non-represented slip monitoring electronics and by means of which the control chamber 35 of the valve arrangement 19 may be relieved towards the unpressurised supply reservoir 29. The circuitry of the 3/2-way solenoid valve 53 may, however, also be chosen such as to ensure that pressure medium that had been tapped from the brake circuit KI, for the purpose of reducing the effective braking pressure in the brake actuating devices, is replaced from the booster chamber of the hydraulic power booster 49 via the storage reservoir 56 in the brake circuit KI.

Upon a removal of the actuating force exerted on the brake pedal 57, at first the brake pedal contact 58 opens. Due to the on-position of the contact 10, the electric motor 17, however, will remain switched on for the time being, thus the pressure medium pump 18 continues to operate. Because of the pressure now lacking in the control chamber of the valve arrangement 19 the action of the force of the compression spring 32 will cause the

piston 31 to adopt the position discernible from the drawing. In this position the valve passage 40, 42 is open, thus the delivery side of the pressure medium pump 18 again communicates with the chamber 9 of the pressure accumulator 1. In the chamber 9 of the pressure accumulator 1 a pressure increase takes place which lasts until the pressure accumulator 1 has reached its predetermined maximum charge and the contact 10 opens.

CLAIMS

1. A hydraulic brake system for automotive vehicles with a master brake cylinder and a hydraulic power booster connected upstream of the master brake cylinder, in which a pressure medium pump which may be driven by an electric motor is used for providing auxiliary hydraulic energy, the drive of which may be switched on by a pressure accumulator, on the one hand, and by a brake pedal contact, on the other hand, in the unbraked operation of the automotive vehicle the pressure accumulator is maintained at a pressure level sufficient for an initial actuation of the brake and the charge of the pressure accumulator is monitored by a pressure control valve, characterised in that a valve passage (40, 42) of a valve arrangement (19) is operable by a hydraulic pressure in the booster chamber of the power booster (49) such as to establish a direct communication between the outlet of the pressure medium pump (18) and the pressure port of the power booster.

2. A hydraulic brake system as claimed in claim 7, characterised in that the valve passage (40, 42) is operable such as to ensure that upon pressurisation of the booster chamber of the hydraulic power booster (49) communication is interrupted between the pressure accumulator (1) and the hydraulic power booster (49).

3. A hydraulic brake system as claimed in claim 1 or 2, characterised in that in a cylinder bore (21) of the valve arrangement (19) a control piston (22) is acconmodated which is displaceable by the delivery pressure of the pressure medium pump against a control force and to establish a communication between the delivery side of the pressure medium pump (18) and an unpressurised supply reservoir (29).

4. A hydraulic brake system as claimed in claim 3, characterised in that the control force is generated by a compression spring (26).

5. A hydraulic brake system as claimed in claim 3 or 4, characterised in that the front face of the control piston (22) which is loaded by the compression spring (26) confines a control chamber (35) hydraulically communicating with the booster chamber of the power booster (49).

6. A hydraulic brake system as claimed in any one of the preceding claims, characterised in that the control chamber (35) hydraulically communicates with a piston (31) which is displaceable against a compression spring to operate a connection between the delivery side of the pressure medium pump (18) and the pressure accumulator (1).

7. A hydraulic brake system as claimed in any one of the preceding claims, characterised in that the pressure in the control chamber (35) of the valve arrangement (19) is influenced by an electromagnetically operable multi-position valve (53).

8. A hydraulic brake system as claimed in claim 7, characterised in that a 3/2-way solenoid valve is used as multi-position valve (53).

9. A hydraulic brake system for automotive vehicles substantially as described herein with reference to the drawing.

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